BioFuelBox licensed technology created by INL researchers Robert Fox (left) and Dan Ginosar for producing biodiesel from oils in municipal waste water, restaurant grease traps and other sources.

INL research helps turn waste grease to fuel

By Mike Wall, *INL Research Communications Fellow*

While oil companies drill deeper and deeper for increasingly hard-to-find petroleum, legions of mini-gushers lie untapped right on the surface. There's one behind every restaurant, for example, and in the heart of every potato-processing plant. Such businesses produce loads of waste grease, a precious resource that can be converted to clean, green biodiesel. And a company called BioFuelBox is doing just that, thanks in part to key research by chemists at Idaho National Laboratory.

Though a young company — its maiden plant in American Falls, Idaho, just started running in August 2009 — BioFuelBox has already made a big splash. BusinessWeek magazine recognized it as one of 2009's 25 most intriguing start-ups, and the World Economic Forum recently named BioFuelBox one of 26 "Technology Pioneers" for 2010. The accolades flow because the company, with INL help, has found a way to make the world's most environmentally friendly, socially responsible transportation fuel — and a profit at the same time.

Using material from a wastewater treatment plant, BioFuelBox has been producing biodiesel in an American Falls, Idaho, pilot plant since August 2009.

The need for renewable diesel

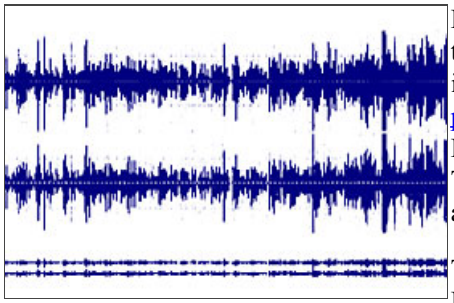
Diesel fuel is the backbone of the U.S. economy, powering the machines of heavy industry and the trucks, trains and boats that transport goods around the country. In 2006, the U.S. burned through 53 billion gallons of the stuff, according to the U.S. Energy Information Administration.

Almost all of this fuel was petrodiesel — diesel refined from crude oil. Since the U.S. imports almost 60 percent of the petroleum it consumes, finding alternative sources of diesel would be a big step forward in the national march toward energy security.

Biodiesel is one such source. This renewable fuel can be made from pretty much any vegetable oil or animal fat, though the vast majority of the U.S. supply comes from soybean oil. While biodiesel remains but a drop in the national tank, its production is growing fast, from 75 million gallons in 2005 to 450 million in 2007.

Putting fuel before food and forest

On balance, the biodiesel boom is probably a good thing; it's helping to diversify the U.S. energy portfolio and reduce the nation's dependence on fossil fuels. However, making fuel out of crops such as soybeans poses some significant ethical, environmental and economic problems.



Listen to the BioFuelBox podcast or read the transcript.

For one thing, using vegetable-oil feedstocks can cause dramatic increases in food prices all over the world. A few years ago, for example, corn prices spiked as demand for corn-based ethanol increased. More recently, the surge in biodiesel production has sent the prices of soybean oil and palm oil soaring. This unfortunate result is most pronounced when food crops are converted to fuels. But it's also a concern even if fuel comes from plants people don't eat, such as jojoba or jatropha. The worry is that farmers might switch to these crops, raising food prices indirectly by reducing the amount of edible crops under tillage.

The growth of plant-based biofuel production has also had serious environmental consequences. Brazil, for instance, is clearing vast tracts of Amazon rainforest to make way for soybean fields. And throughout southeast Asia and tropical Africa, oil-palm plantations are replacing primary rainforest at an alarming rate. This is bad news for tropical wildlife and the fight against climate change: big, ancient forests host lots of biomass and biodiversity and suck far more carbon dioxide out of the air than do managed monocultures.

Finally, making biodiesel from vegetable oil is expensive. The feedstock oils are food-grade quality and therefore pricey. Heavy taxes on petroleum products, such as those imposed by many European countries, have traditionally been necessary for biodiesel to be cost-competitive. In the United

Kingdom, a gallon of petrodiesel averaged $6.79 in mid-December 2009, with taxes accounting for about 64 percent of the price. In the U.S., these numbers were just $2.80 and 19 percent.

But there is a way to make biodiesel work on this side of the Atlantic. You just have to get your hands a little dirty.

Waste greases: an untapped resource

In 1994, INL chemists Bob Fox and Dan Ginosar started thinking seriously about biodiesel. There is, they figured, a good feedstock material out there, one that won't goose global food prices or cause the felling of yet more forest. And the economics could work out, too, if they played their cards right.

"We decided we were going to look at waste oils as our feedstock, and we wanted to get them essentially free," Ginosar says. "The only way to do that is to get the worst waste oils that are out there."

Ginosar and Fox wanted the gunk scraped out of restaurant grease traps, the slime clogging the filters of wastewater-treatment plants. This stuff is pretty much free — people throw it away, after all — but it's a far cry from the clean, golden vegetable oil most biodiesel producers start out with. It's incredibly variable and full of contaminants like flour, dirt and water. So converting it to fuel would require different, and much more robust, chemical methods.

INL technology helps produce the highest quality rated biodiesel (right) from oils contained in municipal waste water, restaurant grease traps and other sources (left).

After much tinkering, Ginosar and Fox came up with a way that works. Most biodiesel producers react vegetable oil with alcohol in the presence of a basic catalyst, such as potassium hydroxide. But the INL chemists substituted an acidic catalyst, because basic ones turned their waste grease to soap. And they injected "supercritical" CO_2 into the reaction. Supercritical fluids are like a mix between a gas and a liquid. In this case, the supercritical CO_2 was key, keeping the alcohol and grease together so they could react.

Ginosar and Fox weren't the first to figure out how to transform waste greases to biodiesel; amateur chemists have been converting used cooking oil in their garages for years. What's special about the pair's technique is its versatility, robustness and efficiency. Their methods can convert a wide range of nasty, contaminated waste greases — the worst of the worst — in addition to relatively clean and uniform cooking oil.

Going to market

Nearly a decade after the breakthrough, the team at BioFuelBox recognized the importance of Fox and Ginosar's findings. The San Jose-based company licensed the chemists' methods a few years ago, integrating them with techniques developed by its own scientists. BioFuelBox is now churning out top-grade biodiesel from the stinkiest waste greases out there. The American Falls facility, which gets its feedstock from a wastewater-treatment plant, has so far produced 43,000 gallons, every one of which meets the most stringent fuel-quality standards.

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This biodiesel can be used in unmodified diesel engines. And because it's made from stuff that would ordinarily be landfilled, it has the lowest carbon footprint of any transportation fuel — about 10 times lower than petrodiesel and four to six times lower than biodiesel made from soybean or palm oil, according to a recent article in the journal Hydrocarbon Processing.

BioFuelBox's product is also competitively priced, even without government subsidies. That's a big accomplishment for a U.S. alternative-fuels manufacturer, and likely a big reason why the company got that Technology Pioneer award from the World Economic Forum. BioFuelBox can make biodiesel relatively cheaply because it gets its feedstock free. Its business model is unique: co-locate smallish, modular biodiesel plants onsite with big producers of waste greases, such as potato-processing facilities.

"You can put the whole plant — all the technical pieces — on two flatbed trucks, bring it in, crane it into place, and then pipe it together," says Rick Reddy, vice president of marketing for BioFuelBox.

This arrangement slashes transportation costs, since the feedstock and the plant are in the same place. The grease producers sign on because BioFuelBox takes the waste off their hands for free. Ordinarily these businesses have to pay disposal fees to get rid of the stuff.

Part of the solution

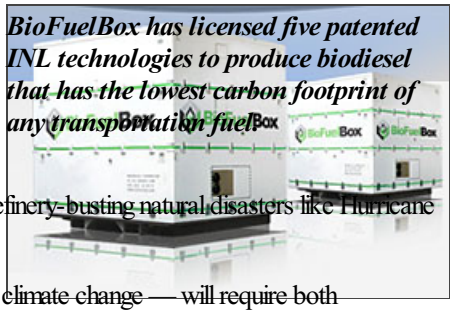
BioFuelBox's future looks bright. The American Falls plant will soon be joined by dozens of others around the country, each one pumping out about a million gallons of biodiesel per year.

"We're looking right now at close to 20 plants that we've already signed up," Reddy says. "And we hope for more."

What's good for BioFuelBox should also be good for the planet. The company estimates that by replacing petrodiesel with waste-generated fuel, each of its plants will prevent the release of 10,000 metric tons of CO_2 per year — the equivalent of taking 2,200 cars off the road. And using waste to make fuel also frees up considerable landfill space.

But waste-grease biodiesel by itself cannot carry the fossil-fuel load. There's just not enough

feedstock out there. Reddy says the world generates about 12 billion gallons of exploitable waste grease every year — but it consumes about 320 billion gallons of diesel.



BioFuelBox has licensed five patented INL technologies to produce biodiesel that has the lowest carbon footprint of any transportation fuel

"There is no silver bullet to solve the world's dependency upon petroleum products," Reddy says. "But this is a step people can take. What's more important, I think, is that businesses and municipalities can become more energy-independent." Cities that produce their own diesel fuel locally would be less affected by swings in the price of oil caused by, say, OPEC machinations or refinery-busting natural disasters like Hurricane Katrina.

The U.S.'s intensifying drive to wean itself off fossil fuels — both to ensure energy security and fight climate change — will require both conservation and the deployment of new technologies. BioFuelBox is starting to show just what is possible on both fronts.

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